TESTUDO

HORIZON-CL3-2022-INFRA-01- Grant Agreement No. 101121258

AUTONOMOUS SWARM OF HETEROGENEOUS RESOURCES IN
INFRASTRUCTURE PROTECTION VIA THREAT PREDICTION AND PREVENTION

D1.3

Mid-term review and progress report

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Abstract	This document provides the reader with an overview of the project's progress during the 1st period (October 2023 – March 2025). It specifically focuses on the work carried out regarding the Project Objectives and Work Packages' (WP) progress and a WP-oriented risk inventory in accordance with the established risk management procedure. The document also briefly describes the planned actions for future WP activities from M19 to M36, following the implementation time plan of the project.

Keywords	Project progress, risk management, work package implementation

Document History

Version	Date	Partner	Remarks
1.0	17.01.2025	CERTH	ToC
1.1	04.03.2025	CERTH	Revised ToC and initiation of input
1.3	24.03.2025	CERTH	Draft for Internal review / SAB review
1.4	31.03.2025	CERTH	Final version

Executive Summary

This deliverable (D1.3) reports on all activities conducted during the first 18 months (M01-M18) of the project, in alignment with the Description of Actions (DoA). The project is progressing according to plan, with minor deviations being managed at the Work Package (WP) level.

The document provides an overview of the project general progress, the submitted Deliverables and achieved Milestones. It details the work completed across all WPs, alongside with identified WP risks, and reports the current status of active WPs. A brief preview of planned activities for the next reporting period (M19-M36) is also included.

During this period, the consortium focused on setting up project efforts and coordinating activities for the design, implementation and evaluation of the first prototype of the TESTUDO platform. Four Milestones were completed, and 14 Deliverables were submitted, including this one. Within WP3 activities, partners collaborated closely with end users to collect, define and analyse the user requirements and use case scenarios that will drive all the development and integration cycles of the project (M01-M09). These efforts culminated in the definition of the initial platform architecture (M13) and the establishment of legal, ethics and privacy requirements relevant to TESTUDO (M18).

WP4, WP6 and WP8 established strong foundational frameworks to support future development phases. During M03-M18, initial functional modules were developed and validated in alignment with the project's architecture and objectives. WP4 delivered a functional version of the Autonomous Fleet Coordinator module (PO.1) and implemented a robust communication layer for cross-asset integration (PO.2). WP6 made significant advancements in AI-driven detection tools tailored to Critical Infrastructure needs, contributing to PO.3 and PO.4. WP8 focused on advancing intelligence capabilities through predictive modelling and data fusion, and developed novel HMI technologies for improved situational awareness (PO.4, PO.5). Additionally, integration activities of modules were performed, and the first prototype was successfully delivered and evaluated through an operational test (M14-M18).

WP10, which commenced in M14, has established comprehensive evaluation methodologies and KPI frameworks whilst undertaking preparatory activities for upcoming pilot demonstrations, and drafting of user training plans to ensure effective testing and validation of the TESTUDO platform. Finally, under WP11 partners participated in various events to promote project results using developed communication and dissemination tools (M6). These structured outreach efforts have enhanced stakeholder awareness and fostered collaboration, supporting knowledge transfer and maximizing TESTUDO's societal and technological impact.

At the end of the second period of the project, D2.2 “Public activity report” will contain a presentation of the consortium, the core project objectives, a summary of key results and the efforts made to maximize TESTUDO’s impact on the use of technologies for Critical Infrastructure Protection.

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Terms and Abbreviations

Label	Text
AI	Artificial Intelligence
BMC	Business Model Canvas
CA	Consortium Agreement
CAD	Computer Aided Design
CBRN	Chemical, Biological, Radiological and Nuclear
CI	Critical Infrastructure
DG HOME	Directorate-General for Migration and Home Affairs
DMP	Data Management Plan
DoA	Description of Action
DT	Digital Twin
EAB	Ethics Advisory Board
EC	European Commission
ECSCI	European Cluster for Securing Critical Infrastructures
EUCI	EU Classified Information
EU-CIP	European Knowledge Hub and Policy Testbed for Critical Infrastructure Protection
GA	Grant Agreement
GDPR	General Data Protection Rule
HMI	Human Machine Interaction
IDS	Intrusion Detection System
IP	Ingress Protection
IPR	Intellectual Property Rights
KER	Key Exploitable Result
KPI	Key Performance Indicator
KR	Key Result
MIP	Mixed-Integer Programming
MS	Milestone
NIS	Directive on security of network and information systems
PO	Project Objective
REA	European Research Executive Agency
SAB	Security Advisory Board
SoA	State of the Art
SfM	Structure from Motion
TRL	Technology Readiness Level
UAV	Unmanned Aerial Vehicle
UC	Use Case
UGV	Unmanned Ground Vehicle
UI	User Interface
UxV	Unmanned Vehicle
WP	Work Package
XAI	Explainable Artificial Intelligence
XR	Extended Reality

1. Introduction

TESTUDO (Autonomous Swarm of Heterogeneous resources in infrastructure protection via threat prediction and prevention) is an international innovation project funded under the Horizon Europe programme in Resilient Infrastructure addressing the HORIZON-CL3-2022-INFRA-01-02 topic. The project aims to develop a highly mature platform for continuous monitoring and surveillance of Critical Infrastructures (CI) that involves harsh and remote environments by utilizing advanced unmanned vehicles and existing equipment as legacy systems. TESTUDO integrates state-of-the-art technologies for detection, prevention, and prediction, improving cognitive capabilities for various hazardous events contributing to the Critical Infrastructure Protection (CIP) domain and to the overall autonomy of relevant systems.

TESTUDO is structured around seven Project Objectives (POs) aligned with the work programme topic, aiming to achieve specific Key Results (KRs). These results will be measured using Key Performance Indicators (KPIs), benchmarked against the State-of-the-Art (SoA), and validated through dedicated WP activities over the project's duration. The TESTUDO POs are described in detail in Section 1.1.1, pages 3-6 in the Grant Agreement (GA)

- PO.1: Synergetic operations of unmanned assets and fixed resources for autonomous surveillance
- PO.2: Secure and efficient telecom networks for remote areas and interoperable devices
- PO.3: Improved AI-based cognitive models for optimal surveillance
- PO.4: Intelligence for prediction and coordinated response
- PO.5: Increased situational awareness via novel HMI technologies
- PO.6: Large-scale and cross-sectorial demonstrators
- PO.7: Identification of potential uptakes and impacts

This document outlines the progress made by the TESTUDO consortium during the first period of implementation (October 2023 – March 2025). In alignment with the EC guidelines for a "lump sum" project, the consortium simplified the implementation process by grouping WPs with identical (technical and non-technical) objectives, divided into two phases: M01-M18 and M19-M36.

During the first eighteen months, the consortium successfully completed six work packages:

- WP1-Project management and coordination v1
- WP3-Risk assessment and requirements definition
- WP4-Augmented sensing and communications for effective autonomy v1
- WP6-Artificial cognitive intelligence for threat identification v1
- WP8-Predictive intelligence, operational support, and platform implementation v1
- WP11-Impact creation and outreach v1

One work package, WP10 (Large-scale pilot execution and evaluation), remains active and will continue its implementation during the second period.

The report initially provides an overview of the project, including the timeline, submitted deliverables, and achieved milestones. It then details the progress per work package and task, highlighting key achievements selected by WP/task leaders towards implementing the Project's Objectives. For specific WPs, progress is also reported per PO, which are linked to one or more work package objectives and content. A risk inventory is maintained per WP to closely monitor identified risks and evaluate the need

for mitigation actions. Moreover, future action points are listed for WP10 and the six WPs that will be active in the second period of the project, demonstrating the consortium plans for the upcoming period (both long- or short-term). Finally, the document concludes with a summary of what has been reported throughout the deliverable.

2. Overview of progress

This section is focused on the project's overall progress throughout M01-M18 (October 2023 – March 2025). First, general project information is presented, including the project timeline and implementation structure, illustrated in a Gantt chart, along with the successfully submitted deliverables and achieved milestones. Section 2.2 provides a detailed account of the completed work, the risks that have been identified for each WP and the response to them, the main highlights of WPs and associated tasks, and possible deviations according to the project's Grant Agreement. Section 2.3 presents an overview of the WP10, which remains active across both project periods. Finally, Section 2.4 outlines the future work for WPs that will commence in the project's second period and remain active until its completion, building on the efforts initiated during the first period.

2.1. General Progress

The project's progress during the reported implementation period has been both highly productive and in line with the plan outlined in the Description of Action (DoA). After 18 months, the consortium has already achieved several planned results and is on track to deliver the final version of the TESTUDO platform with all its capacities and functionalities by the end of the second period. In the next page, Figure 1 presents the TESTUDO Gantt chart, where light blue indicates completed WPs (WP1, WP3, WP4, WP6, WP8, and WP11), light green depicts the WP active across both project periods (WP10), and light orange highlights the WPs planned for the second period (WP2, WP5, WP7, WP9, and WP12).

During these eighteen months of TESTUDO's implementation, 9 out of 14 deliverables were submitted on time, while 5 out of 14 deliverables experienced minor delays. These delays were necessary to ensure the required level of detail and quality that is required by the project. The first four milestones have been successfully achieved, reflecting steady progress. Table 1 outlines the deliverables submitted, the related WP, their lead beneficiaries, the type, the dissemination level, as well as their due and actual submission dates. Table 2 provides an overview of all milestones listed in the Grant Agreement (GA), highlighting those completed to date along with their leader, means of verification, and due dates. The actions taken towards the achievement of these milestones may found in Section 2.2 where the progress is reported per WP/task.

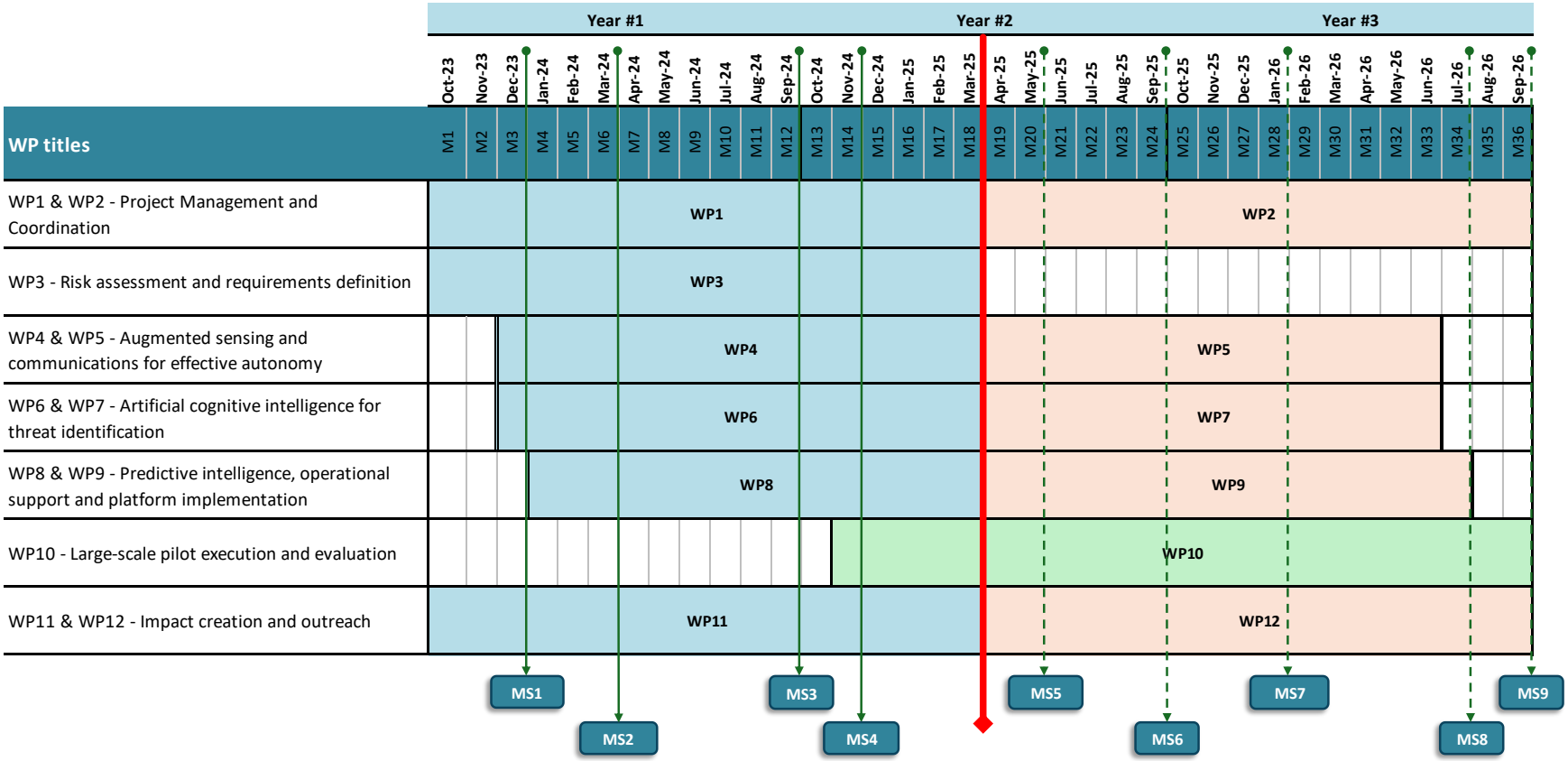

Figure 1. TESTUDO Gantt chart with progress

Deliverable No	Deliverable Name	Work Package No	Lead Beneficiary	Type	Dissemination Level	Due Date (month)	Submission Date (month)
D1.1	Project management and quality assurance handbook	WP1	1 - CERTH	R — Document, report	SEN - Sensitive	Dec. 2023	Dec. 2023
D1.2	Initial data management plan	WP1	18 - LIF	DMP — Data Management Plan	SEN - Sensitive	Mar. 2024	Apr.2024
D1.3	Mid-term review and progress report	WP1	1 - CERTH	R — Document, report	PU - Public	Mar. 2025	Mar. 2025
D3.1	Risk assessments	WP3	10 - PROS	R — Document, report	SEN - Sensitive	Jun. 2024	Jul.2024
D3.2	Identification of use case scenarios and user requirements	WP3	17 - ADS	R — Document, report	R-UE/EU-R - EU Classified	Jun. 2024	Jul. 2024
D3.3	Platform architecture and technical requirements	WP3	3 - STWS	R — Document, report	SEN - Sensitive	Sep. 2024	Oct. 2024
D3.4	Legal and ethical framework of TESTUDO	WP3	18 - LIF	R — Document, report	SEN - Sensitive	Mar. 2025	Mar. 2025
D4.1	Augmented sensing and communications v1	WP4	7 - ENG	R — Document, report	SEN - Sensitive	Mar. 2025	Mar. 2025
D6.1	Cognitive intelligence for threat identification v1	WP6	11 - VICOM	R — Document, report	SEN - Sensitive	Mar. 2025	Mar. 2025
D8.1	Models for predictive intelligence and fast response v1	WP8	20 - CENTRIC	R — Document, report	SEN - Sensitive	Mar. 2025	Mar. 2025
D8.2	First version of the TESTUDO platform	WP8	4 - NTTD IT	R — Document, report	SEN - Sensitive	Mar. 2025	Mar. 2025

D11.1	Dissemination plan and communication materials	WP11	8 - PIAP	R — Document, report	PU - Public	Mar. 2024	Apr. 2024
D11.2	Activity report on dissemination activities and policy making	WP11	19 - DBC	R — Document, report	SEN - Sensitive	Mar. 2025	Mar. 2025
D11.3	Exploitation plans and impact pathways assessment	WP11	19 - DBC	R — Document, report	PU - Public	Mar. 2025	Mar. 2025

Table 1. List of submitted deliverables.

Milestone No	Milestone Name	Work Package No	Leader	Means of Verification	Due Date
1	Project setup	WP1, WP11	1-CERTH	Deliverables: D1.1 Reports: Dissemination materials	December 2023
2	Data management and dissemination plans	WP1, WP11	8-PIAP	Deliverables: D1.2, D11.1 Reports: 1st periodic report	March 2024
3	User requirements and platform architecture	WP3, WP1	3-STWS	Deliverables: D3.1-D3.4 Reports: 1st periodic report	September 2024
4	Delivery of the 1st prototype	WP3, WP4, WP6, WP8	4-NTTD IT	Deliverables: D10.2, D11.2 Reports: 1st periodic report	November 2024

Table 2. List of Milestones.

2.2. Completed work packages

2.2.1. WP1 - Project Management and Coordination v1

Leader	CERTH	**Contributors**	CERTH, ACCELI, STWS, NTTD-IT, EYDAP, CEA, ENG, PIAP, T4I, PROS, VICOM, SINTEF, DFKI, INTER, TEKN, DRAXIS, ADS, LIF, DBC, CENTRIC
Start month	October 2023	**End month**	March 2025
Objectives	The main objectives of the WP are to: (i) to provide overall project management and coordination; (ii) interface between partners and relevant external stakeholders; (iii) monitor, track and control quality as well as risks and deviations due to progress, cost, financial and planning changes; (iv) develop the data and IPR management plan; and (v) monitor the security, ethical, legal, and privacy management for the whole duration.		
Related Project Objectives	There are no POs related to WP1 objectives and content.		

T1.1 – Project management, administration and reporting (CERTH)

Overall progress and reporting

During the reporting period (M01–M18), several activities were carried out under T1.1 'Project Management, Administration, and Reporting'. The project management team, in close collaboration with all project tasks, played a central role in ensuring seamless coordination, effective communication, and the alignment of objectives across all partners and WPs.

- A management team was established by the coordinator to ensure smooth day-to-day management of the project.
- Essential project infrastructure, including the project repository, mailing lists, and collaboration tools, was set up in M01.
- Dedicated meetings for each active WP were introduced gradually from M01, with the purpose to monitor the advancement of all tasks according to the project timeline and POs, and to coordinate information flow and effective communication between partners.
- A monthly WP Alignment meeting was introduced in June 2024 (M9) to inform WP leaders and Task leaders about key developments across WP activities and enable decision-making at the consortium level.
- Milestone #1, focused on Project Setup, was achieved in M03, including the submission of D1.1 and dissemination materials.
- Two pre-financing payments were successfully completed on time following the Consortium Agreement.
- Two plenary meetings were held (in San Sebastián, Spain, and Athens, Greece) with the participation of all partners in M06 and M12, with a third planned for M19.
- Two General Assembly Meetings were successfully conducted in conjunction with the project's plenary meetings, with a third planned for M19.
- Two internal reports were prepared and finalized with input from all partners.

- The activities from this period are reported in D1.1 and D1.3.

Identified issues/deviations

No deviations from Annex 1 of the GA were reported, and all activities remain on track with the planned schedule and allocated resources.

T1.2 – Quality control and risk management (CERTH)

Overall progress and reporting

During this reporting period, under T1.2 'Quality Control and Risk Management,' the CERTH-led team ensured rigorous quality monitoring, risk mitigation, and timely corrective actions to align project progress with objectives, timelines, and resource constraints. The following key developments took place:

- A comprehensive risk log for all Work Packages (WPs) was created and continuously updated through two plenary meetings held during this period. The risk log has also been revisited during the monthly WP alignment meetings.
- Two internal reviews were successfully conducted to track, monitor, and evaluate project progress.
- All deliverables submitted during the reporting period—namely D1.1, D1.2, D3.1, D3.2, D3.3, D3.4, D4.1, D6.1, D8.1, D8.2, D11.1, D11.2 and D11.3 —underwent a quality control check and security assessment by the Security Advisory Board (SAB).
- Ongoing project monitoring was ensured through active participation in all regular WP web meetings, as well as during the monthly WP Alignment Meeting, to identify risks and maintain implementation quality.
- Based on feedback from multiple partners, the project templates introduced in M01 were updated within the first semester to enhance quality, efficiency, and consistency.
- D1.1 and D1.3 analytically detail the progress of activities undertaken in T1.2.

Identified issues/deviations

No deviations from Annex 1 of the GA were reported, and all activities remain on track with the planned schedule and allocated resources.

T1.3 – Scientific and technical management (STWS)

Overall progress and reporting

During the reporting period under discussion (M01–M18), the project's technical coordination team, in close collaboration with T3.3 activities, played a pivotal role in establishing a unified technical perspective among project partners. To achieve this, continuous communication was maintained at both bilateral and WP/Project levels, ultimately shaping a comprehensive technical architecture that integrates the various tools of TESTUDO under a cohesive operational framework. Additionally, significant efforts were dedicated to defining precise technical requirements, which will serve as a foundation for guiding technical development in the later stages of the project. This task also contributed to ensuring that the project's technological advancements align with its overarching objectives.

As a result of these coordinated efforts, a robust technical architecture for the TESTUDO platform was formulated. Furthermore, during this initial project phase, discussions within T1.3 focused on establishing a validation framework. This framework aims to define Key Performance Indicators (KPIs) that adhere to the SMART principle to the greatest extent possible, ensuring effective validation of TESTUDO. In this context, the deployment plan for pilot implementations was developed, considering critical aspects such as timing, resource allocation, and technical requirements. Extensive collaboration was also undertaken to refine procedures for optimizing the technical execution of pilot activities, thereby supporting the successful achievement of project objectives. This approach has led to the successful completion of the first UC1 (integration test).

Finally, all deliverables with technical content scheduled for submission within this period —including D3.1, D3.2, D3.3, D4.1, D6.1, D8.1 and D8.2— underwent the necessary quality assurance processes to ensure scientific rigor and alignment with the envisioned technical architecture. The activities from this period are reported in D1.3.

Identified issues/deviations

No deviations from Annex 1 of the GA were reported, and all activities remain on track with the planned schedule and allocated resources.

T1.4 – Data and IPR management (LIF)

Overall progress and reporting

Significant preparation for and execution of T1.4 were carried out. A Data Management Plan (DMP) was created and then circulated among Consortium Partners with the request to fill in all relevant data. The sections in the template covered topics related to data management, such as ethics, security, FAIR principles, etc. The core goal in that regard was to outline how the generated and processed data are being handled during the project and after its completion.

D1.2 “Initial Data Management Plan” was also completed during this period, contributing to the achievement of Milestone #2. D1.2 outlined the applicable legal and ethical framework to the project (in the context of protection of fundamental rights, privacy, personal data, data security and EU-classified information, research integrity, etc.). It also presented identified risks and proposed mitigation measures concerning privacy and security, as well as AI-related issues. Following that, the deliverable summarised the responses provided in the DMP Collector and outlined the applicable data management policy covering data collection, processing, and management, as well as the FAIR principles.

In addition, D1.2 covered the management of project knowledge, thereby ensuring proper implementation and maintenance of the legal aspects of the partnership as described in the Consortium Agreement (CA), as well as monitoring adherence to the CA and Intellectual Property Rights (IPR) management strategy. The activities from this period are reported in D1.2.

Identified issues/deviations

No deviations from Annex 1 of the GA were reported, and all activities remain on track with the planned schedule and allocated resources. D1.2 was submitted with a minor delay to ensure its quality and level of detail.

T1.5. Security, privacy, ethics and legal monitoring (LIF)

Overall progress and reporting

T1.5 builds on T1.4, with the aim of securing continuous and rigorous monitoring within the project. Internal planning of topics and scheduling for future regular workshops aimed at training partners on compliance with the security, ethical, legal, and privacy requirements associated with the project has been conducted. Due to strong interdependencies with T3.3, these workshops were co-organised with WP3 during this reporting period. Finally, the Ethics Advisory Board (EAB), which oversees the TESTUDO's compliance with ethical principles and relevant legislation, was established. Participation in the EAB has been confirmed by CENTRIC, CERTH and LIF, and online meetings have commenced. Activities will be reported in D2.1 "Security, ethics, legal, IPR management and final data management plan" [LIF, M36]

Identified issues/deviations

No deviations from Annex 1 of the GA were reported, and all activities remain on track with the planned schedule and allocated resources.

Deliverables submitted

- D1.1 "Project management and quality assurance handbook" - [CERTH, M3]
- D1.2 "Initial Data Management Plan - [LIF, M7]
- D1.3 "Mid-term review and progress repost" – [CERTH, M18]

Progress per Project Objective

There are no POs related to WP1 objectives and content

Risk Inventory

#	Description	Likelihood	Impact	Response
Risk 1	Interpersonal tensions among partner representatives, communication gaps, and misinterpretations.	Medium	Medium	Recurrent and open communication with partners for cultivating a positive collaborative environment. Promoting personal and virtual bilateral and meetings, alongside consortium gatherings to ensure the smooth implementation of the project.
Risk 2	Inadequate performance quality of results.	High	High	Continuous review of progress and results by Coordinator, Technical and Scientific Managers.
Risk 3	The preparation of 8 Deliverable Reports in M18 and the periodic reporting might result in delays in project reporting.	Medium	High	Start preparing Deliverable reports within M15. Ensure a high level of communication between contributing partners and cross check contributions before submission.

Risk 4	Lack of clarity in roles and responsibilities among consortium members.	Medium	Medium	Establish specific responsibilities early. Review and re-establish roles as the project progresses to ensure alignment and clarity among partners.
Risk 5	Unexpected costs or budget overruns in specific work packages.	Medium	Medium	Maintain a budget control mechanism to provide warning in time for potential remedy actions.
Risk 6	Key staff members leaving their organizations during the project lifetime.	High	Medium	Developing contingency plans for key personnel changes.
Risk 7	Violation of AI act or related legal and ethical frameworks by research activities.	Medium	Medium	Monitoring and oversight of research activities by LIF, along with consultation by the Ethics Advisory Board and Security Advisory Board of the project.
Risk 8	Unwanted disclosure of SENSITIVE or EUCI information.	High	High	Provide a guideline for security procedures and consult SAB for assessment of material. Use approved encryption method for information exchange.
Risk 9	Resource allocation not aligning with the set milestones and project goals.	Low	Medium	Implement a dynamic resource management strategy, establish a contingency reserve, and periodically review and adjust project timelines.
Risk 10	Partner insolvency or bankruptcy during project implementation.	Medium	High	Establish contractual provisions for assignment of tasks and resources in case of partner insolvency. Develop contingency plans for task redistribution among remaining partners. Maintain open communication channels with the Project Officer about potential financial difficulties.

Table 3. Risk Inventory for WP1

2.2.2. WP3 - Risk assessment and requirements definition

Leader	PROS	**Contributors**	CERTH, ACCELI, STWS, NTTD-IT, EYDAP, CEA, ENG, PIAP, T4I, PROS, VICOM, SINTEF, DFKI, INTER, TEKN, DRAXIS, ADS, LIF, CENTRIC
Start month	October 2023	**End month**	March 2025
Objectives	The WP aims to: (i) involve the correct stakeholders along with the users of the consortium to create the required usage scenarios and develop the user requirements, (ii) provide a legal and ethical framework to ensure ongoing compliance with the legal and ethical requirements, and (iii) define the technical specifications and design the envisaged platform.		

Leader	PROS	Contributors	CERTH, ACCELI, STWS, NTTD-IT, EYDAP, CEA, ENG, PIAP, T4I, PROS, VICOM, SINTEF, DFKI, INTER, TEKN, DRAXIS, ADS, LIF, CENTRIC
Related Project Objectives	There are no POs related to WP3 objectives and content.		

T3.1 – User driven risk assessment and use case design (PROS)

Overall progress and reporting

The Task has been completed according to the project plan.

- The PROS team organized visits to all three Critical Infrastructure sites in Spain and Greece.
- Relevant regulations were analysed, including the specific features of each infrastructure site and their areas of influence.
- A catalogue of threats to the physical and logical security of each infrastructure was developed through in-depth analysis, based on the principles of the ISO/IEC 31000:2009 standard and the Reference Security Management Plan (RSMP) developed by the European Commission.
- The study methodology, implementation process, and characteristics of each CI were compiled in D3.1 “Risk Assessments”.
- Section 6 (Risk Assessment) from D3.1 was included in ANNEX 3 of D3.2, "Identification of use case scenarios and user requirements", due to its confidentiality level. This section contains data on CIs that have been classified as RESTREINT UE/EU RESTRICTED. Given that D3.1 is classified as "SENSITIVE", Section 6 was incorporated into D3.2, classified as "EUCI", following EU consultation.
- Use cases were defined for each infrastructure based on the collected data.
- A WP3 physical meeting on Risk assessment and Use Case Design was organized in March 2024 in Berlin, Germany, with contribution by PROS.
- With the finalization and delivery of both D3.1 and D3.2, the task was completed.

Identified issues/deviations

No deviations from Annex 1 of the GA were reported, and all activities remained on track with the planned schedule and allocated resources. D3.1 was submitted with a minor delay in early July 2024 to achieve the necessary level of detail for this project.

T3.2 – User requirements specification and analysis (ADS)

Overall progress and reporting

T3.2 has been completed according to the project plan:

- ADS co-led weekly WP3 meetings with PROS until D3.2. “Identification of use case scenarios and user requirements” was completed.
- Active participation in cross-task development activities, addressing the close and complex interdependencies between WP3 tasks, such as T3.1 and T3.4, for cohesive workflow and integration.

- A holistic approach to defining well-structured end-user requirements was introduced and executed, ensuring clarity and alignment with project goals.
- The need for a TESTUDO service catalogue was identified. Hard and soft service catalogue items were mapped in collaboration with technical partners, enabling clear and concise use-case design.
- Leading partners were linked to specific KPIs, based on Tasks assessments.
- Initial functional and non-functional requirements list was prepared, reviewed in regular WP3 meetings led by ADS and was finalized for D3.2.
- Use-case scenario definition was co-organised by ADS and PROS.
- A WP3 physical meeting for User Requirements Definition and Use Case Design was organized with contribution by ADS in March 2024 in Berlin, Germany.
- D3.2 was prepared for submission, ensuring the document conforms to the EU Classified dissemination level. With the finalization and delivery of D3.2, the task was completed.
- Following consultation with the project officer, the content of D3.2 was expanded to incorporate the 'Risk Assessments' section from D3.1, combining all EU-R classified content into a single comprehensive document.
- ADS participated and contributed to D3.3 “Platform architecture and technical requirements” reviews.

Identified issues/deviations

No deviations from Annex 1 of the GA were reported, and all activities remained on track with the planned schedule and allocated resources. D3.2 was submitted with a small delay in July 2024 to ensure the necessary quality and quantity of user requirements for this project and the deliverable’s compliance to the classification level of information. Further amendments will be reported in D10.1 and D10.2.

T3.3 – Legal, ethical and privacy governance (LIF)

Overall progress and reporting

The core regulatory and ethical framework that has been identified and reviewed within the context of the project includes the following:

- Regulation (EU) 2023/2854 “Data Act”;
- Directive (EU) 2022/2557 “Critical Entities Resilience”;
- Directive (EU) 2022/2555 NIS2; Directive (EU) 2016/1148 “Security of network and information systems” (NIS);
- Regulation (EU) 2024/1689 “Artificial Intelligence Act”;
- Ethics Guidelines for Trustworthy AI;
- Regulation 2016/679 GDPR;
- Regulation (EU) 2018/1807 on the free flow of non-personal data.

In addition, LIF has commenced with the preparation of an ongoing Legal & Ethical Online Workshop Series, starting with a two-part interactive AI Ethics Workshop. Due to strong interdependencies with T1.5, these workshops were co-organised with WP1 during this reporting period.

Last but not least, the TESTUDO project reached out to a wider audience as its legal Consortium partner, LIF, presented a paper during the 2024 Scientific Conference held by the Faculty Command and Staff at

the National Defence College of Bulgaria. The report was titled “Ethical & Legal Responsibility for Artificial Intelligence: The Regulatory Framework for High-Risk AI Systems.” and delved into the complex landscape of AI regulations as outlined in the AI Act, with a particular focus on high-risk AI systems. D3.4 “Legal and ethical framework of TESTUDO” was also prepared during this period and was submitted in March 2025.

Identified issues/deviations

No deviations from Annex 1 of the GA were reported, and all activities remained on track with the planned schedule and allocated resources.

T3.4 – Technical requirements specifications and platform architecture (STWS)

Overall progress and reporting

During the first reporting period of TESTUDO project, work has primarily focused on the data collection and the mapping of key requirements into a solid technical architecture for facilitating the later efficient realization of the TESTUDO platform, which have been reported in D3.3. In this context, the main activities completed during the period under consideration include:

- **Comprehensive Data Collection on Technical Modules**
  An extensive data collection process has been completed detailing the specifications of the TESTUDO Technical Modules, which was systematically compiled in a file. The collected data served as a vital repository of technical specifications, encompassing essential aspects such as operational functions, performance parameters, and integration requirements. This structured documentation played a pivotal role in guiding the development of each module, ensuring they meet both technical and operational project needs.
- **Mapping of User Requirements to Technical Specifications**
  A mapping of user requirements to technical specifications was conducted to align the development of TESTUDO Technical Modules with end-user operational needs. This process ensures that the system remains user-centric and functionally robust.
- **Analysis of Integration Requirements in Use Case Contexts**
  The integration requirements of TESTUDO Technical Modules were examined in relation to real-world use cases. This assessment is critical in ensuring that the solution is practical, adaptable, and effective across diverse operational scenarios.
- **WP3-Related Discussions**
  Regular WP3-related calls were realized, focusing on interoperability and system architecture. These discussions facilitate collaborative development and the seamless integration of the TESTUDO framework into existing infrastructures.
- **Formulation of TESTUDO Technical Architecture**
  The formulation of the TESTUDO technical architecture was driven by a structured approach that integrated comprehensive data collection, user requirements mapping, and analysis of integration needs. By systematically documenting the specifications of the TESTUDO Technical Modules and aligning them with operational requirements, a solid foundation was established to ensure the platform's functionality, interoperability, and scalability. Insights from real-world use cases and collaborative discussions within WP3 further refined the architectural framework, facilitating the seamless integration of TESTUDO within existing infrastructures and paving the way for its efficient implementation.

Identified issues/deviations

No deviations from Annex 1 of the GA were reported, and all activities remained on track with the planned schedule and allocated resources. D3.3 was submitted with a slight delay in October 2024, following the delay of D3.2 submission, to maintain high quality in the technical implementation.

Deliverables submitted

- D3.1 “Risk Assessments” - [PROS, M10]
- D3.2 – “Identification of use case scenarios and user requirements” - [ADS, M10]. The deliverable, classified as EU-R, also incorporated the 'Risk Assessments' section from D3.1 for convenience, allowing the EU-R information from both deliverables to be collated into one document.
- D3.3 “Platform architecture and technical requirements” - [STWS, M13]
- D3.4 “Legal and ethical framework of TESTUDO” - [LIF, M18]

Progress per Project Objective

There are no POs related to WP3 objectives and content

Risk Inventory

#	Description	Likelihood	Impact	Response
Risk 1	Low number and poor quality of Users’ requirements identified.	Medium	Medium	A list of potential requirements will be proposed to the final users in order to ease the task of requirements identification. Agreement of the requirements should be achieved in a physical meeting. Iterations in the process will be performed to ensure the quality.
Risk 2	Lack of information to carry out the cybersecurity risk assessment of the Depuration Plant.	High	Low	An analysis based on simple responses to a questionnaire will serve as a basis to identify the main communications infrastructure situation and vulnerabilities. Based on it, a cyber-risk assessment can be performed achieving the necessary level of detail for this project.
Risk 3	Due to the numerous technical components engaged in TESTUDO, the architecture definition process may be impacted due to the increased complexity, prolonging the respective deliverable elaboration and submission.	Medium	Low	Timely initiate the respective content elaboration process following the establishment of a commonly agreed document structure. Recurrent communication held with responsible technical partners for ensuring the taking of all necessary steering decisions towards minimizing any delays / ensuring that these will not impact on the critical implementation path of the project.

Risk 4	D3.2 is an EUCI deliverable and is (and will be) referenced in many other deliverables. This causes additional effort and complexity in obfuscating the D3.2 data.	Low	Low	Initial forecasting and clear communication of how to include references to D3.2, in the most secure way.
Risk 5	Need to potentially implement mechanisms for bias evaluation, verification, and traceability to ensure compliance with Ethical AI principles and the EU AI Act, particularly for AI systems classified as high-risk within the project.	Low	Medium	Analysis of AI applications in TESTUDO use cases within WP3, with communication and monitoring alongside technical partners. All partners are actively participating in Ethics workshops to build their capacity to identify potential risks linked to AI use.
Risk 6	Data quality and completeness risks associated with the gathered specifications may lead to re-evaluation and additional data collection.	Low	Medium	Periodic data quality reviews, potential re-evaluation, additional data collection, and resource adjustment for potential rework.

Table 4. Risk Inventory for WP3

2.2.3. WP4 - Augmented sensing and communications for effective autonomy v1

Leader	ENG	**Contributors**	CERTH, ACCELI, NTTD-IT, CEA, ENG, PIAP, T4I, PROS, SINTEF, DFKI, INTER, TEKN, DRAXIS, ADS
Start month	December 2023	**End month**	March 2025
Objectives	The WP has the following development objectives: (i) design and develop a secure network of communication for the involved assets, (ii) define the sensors used for optimal monitoring of the CIs, (iii) develop robust/ secure coordination of all the autonomous edge devices for optimal coverage, (iv) develop mission definition models for commanding the available assets, (v) develop 3D representation models for increased synergy with the DTs and XR technologies.		
Related Project Objectives	PO.1: Synergetic operations of unmanned assets and fixed resources for autonomous surveillance PO.2: Secure and efficient telecom networks for remote areas and interoperable devices		

T4.1 – Interoperable network architecture for robust/secure communications (CEA)

Overall progress and reporting

Within the objectives of the task and the first period, existing state of the art methods were evaluated on wireless mesh networks for robotic communications. In addition, the project needs were assessed during the second plenary meeting in Athens in November 2024. Finally, an initial version of the network controller was developed based on SDN (Software Defined Networking) for mesh networks. The controller is designed for robotic platforms, especially with limited bandwidth and/or computational resources. Tests were performed for the initial versions of the controller using a 3 hop network and a robotic platform equipped with LiDAR and camera sensors. The monitoring and control capacities of the controller in

adapting network topology during robotic control and streaming flows were demonstrated. Activities are reported in D4.1, with a detailed presentation of the robotic control testbed.

Identified issues/deviations

There are no significant deviations from the project's planned objectives at this stage. The implementation is progressing as expected.

T4.2 – Interoperable data model for comprehensive incident description and forensic procedures (ENG)

Overall progress and reporting
This task aimed to develop an interoperable data model for CI, specific to the TESTUDO project. IDMEF examples have been shared among partners, and ENG collected information from everyone to facilitate communication, also in alignment with T4.3 activities. Moreover, ENG has provided an example of IDMEF format specific for TESTUDO, and this has been adapted to specific cases. In addition to these actions, T4.2 has initiated collaboration with WP8, specifically T8.1, due to the strong interconnection between these two tasks.

Within the project scope, the version of IDMEF adopted is 2.D.V03, which was the latest version available at the time of development. To support all partners in adopting this standard, ENG has provided various examples and dedicated sessions. A general example and more specific examples are mentioned in Section 2.2 of D4.1 "TESTUDO Data Model for CI Protection", along with a detailed description of the overall T4.2 activities.

Identified issues/deviations

There are no significant deviations from the project's planned objectives at this stage. The implementation is progressing as expected.

T4.3 – Sensor infrastructure for autonomous surveillance (TEK)

Overall progress and reporting
The primary objective of this task is to design, develop, maintain, and support a robust communication infrastructure that facilitates seamless interaction between all partner modules within the project. In this context, significant efforts have been undertaken to establish a communication server, which efficiently receives and processes messages from various connected devices. Additionally, a dedicated VPN network has been implemented to ensure secure and reliable communication, preventing data transmission over the open internet and thereby enhancing cybersecurity and data integrity.

A key focus has been placed on providing comprehensive support to all partners in integrating with this infrastructure. This includes assisting with the setup of VPN connections, offering technical guidance, and supplying code examples to streamline the connection process. These efforts aim to minimize integration challenges, accelerate adoption, and ensure that all participants can leverage the communication system effectively and securely. Contributions have been made to D4.1 detailing the development done.

Identified issues/deviations

There are no significant deviations from the project's planned objectives at this stage. The implementation is progressing as expected.

T4.4 – Collective intelligence for swarming autonomy (SINTEF)

Overall progress and reporting

This task involves the collection of all the intelligence relevant for the SWARM-level mission planning for the autonomous edge devices. A key activity in this work has been to develop a suitable simulator that can support the development and verification work associated with T4.4 and T4.5. A *minimum functionality* ROS2-based simulator framework is now in place and is being continuously improved and expanded to align with evolving project developments and requirements.

To allow the insertion of realistic UxV performance, regular meetings with the UxV developers have been arranged and have resulted in a mapping of relevant capabilities and limitations for each mobile platform. Additionally, the initial versions of algorithms for spatial and temporal 3D coverage assessment for both UGVs and UAVs have been developed. To improve coverage efficiency in the TESTUDO use cases, strategic robot viewpoints were generated and integrated with the work in T4.5, which optimizes the sequence of their visitation. Contributions are described in detail in D4.1.

Identified issues/deviations

There are no significant deviations from the project's planned objectives at this stage. The implementation is progressing as expected.

T4.5 – High-level mission definition for optimal resources allocation (SINTEF)

Overall progress and reporting

This task focuses on developing algorithms for assigning and dispatching autonomous resources, optimizing their deployment to effectively address security threats to the installation. To tackle the optimization problem, an initial Mixed-Integer Programming (MIP) formulation was developed. Higher performing search methods are planned for development in WP5, to achieve the computation efficiency required by the application. These optimization models ensure that each UxV follows an optimal path and schedule, maximizing surveillance coverage while minimizing travel distance and energy consumption.

Internally, two key algorithms perform the following tasks:

- **Graph Reduction:** Constructing a travel graph for UxVs that is as compact as possible.
- **Routing and Scheduling:** Optimizing UxV routes and schedules on this graph to enhance surveillance efficiency.

Additionally, a basic interface has been developed for internal testing, allowing simulation-based validation without requiring integration with other TESTUDO components. Contributions are described in detail in D4.1.

Identified issues/deviations

There are no significant deviations from the project's planned objectives at this stage. The implementation is progressing as expected.

T4.6 – Three-dimensional representations of geometric data (CERTH)

Overall progress and reporting

The goal of the 3D mapping task is to provide the methodology for the generation of a virtual 3D map of CIs through visual content, specifically from images captured by UAVs. For this purpose, the designed pipeline initially takes RGB images captured by UAVs as input to a Structure from Motion (SfM) component where a Point Cloud is generated. The images, along with the previous component of the pipeline, are used to train a supervised 3D representation model using an appropriate software library. Finally, the visualization of the 3D representation was implemented with the use of an appropriate 3D representation engine. The 3D model will be loaded to the Command and Control System to help the end users gain a better overview of the CI and prevent future threats. The proposed pipeline and test results are presented in D4.1.

Identified issues/deviations

There are no significant deviations from the project's planned objectives at this stage. The implementation is progressing as expected.

Deliverables submitted

D4.1 “Augmented sensing and communications v1” - [ENG, M18]

Progress per Project Objective

The activities carried out within WP4 have been instrumental in advancing the POs, particularly through the ongoing development and validation of an initial functional version of the Autonomous Fleet Coordinator module (see tasks 4.4 and 4.5 for PO.1). The focus has been on establishing a working tool that incorporates all key elements of the complete solution, laying the groundwork for further optimization and testing. The assessment of relevant KPIs was initiated in WP4 and will progress in WP5. Initial testing has been conducted with limited complexity, providing a preliminary evaluation of performance. However, some tests have not yet been performed due to the low number of drones (ground and aerial) currently included in the evaluations. These factors highlight the need for further refinements and expanded testing in the next phases of the project, under WP5 activities.

In relation to PO.2, the activities within WP4, particularly T4.1, were performed in close collaboration with other technical WPs to ensure stable, secure, and high-bandwidth connectivity between the involved assets, both mobile and fixed. This effort aligns with the TESTUDO versatile architecture, which is designed to address multiple operational needs depending on the specific requirements for CIP. The continuous collaboration across work packages is essential for refining these capabilities and achieving seamless integration of the communication layer within the overall system architecture. The progress achieved so far within WP4 has established a strong foundation for these upcoming improvements, ensuring that the project continues to move toward its targeted objectives.

Risk Inventory

#	Description	Likelihood	Impact	Response
Risk 1	Difficulties in data exchange between software and hardware components, and the UAVs and UGVs.	Medium	Medium / High	Conduct regular interoperability testing sessions using prototypes to identify and resolve compatibility issues at an early stage. Provide detailed and consistent documentation for all software components to facilitate understanding and implementation. Use simulation environments or emulators to test software integration before deployment on physical UAVs and UGVs. Collaboration and Communication between partners on these activities.
Risk 2	Data acquisition for 3D representation (on-time permissions for drone flights due to local restrictions, timing constraints, drones' availability and waypoint definition).	High	Medium / High	Schedule early activities.
Risk 3	Not able to keep the responsible human operator in the loop when replanning the paths of the robots in response to dynamic events.	Medium	Medium	Need to define a detailed step-by-step scenario description that also identifies the human involvement in the control of each robot. Start to discuss strategies for keeping the relevant humans in the loop.
Risk 4	Not possible to operate the robots efficiently due to the risk of injuring people.	Medium	Medium / High	Work on the detailed step-by-step scenario description to clarify the necessary presence of people when the robots are operating, during the pilot execution.
Risk 5	Not enough link throughput/latency for uplink streaming.	Medium	Medium	Applications can adapt their streaming resolution in case of degraded throughput.
Risk 6	If radios on drones do not provide a robust connectivity to reach for gateway.	High	High	We intend to use multi-hop mesh connectivity using our centralized controller. The routing can be done with stationary routers on the ground or through other drones running our controller. When possible, we can add high gain antennas. Testing on site or in similar distances is potentially required.
Risk 7	Safety risk of testing communication quality during drone operation.	High	High	Do initial mesh connectivity tests using artificial traffic flows while the drones communicate through their traditional radios on the ground nearby each drone.

Table 5. Risk Inventory for WP4

2.2.4. WP6 - Artificial cognitive intelligence for threat identification v1

Leader	CERTH	**Contributors**	CERTH, ACCELI, STWS, NTTD-IT, CEA, ENG, PIAP, T4I, VICOM, DFKI, TEKN, CENTRIC
Start month	December 2023	**End month**	March 2025
Objectives	The WP has the following technical objectives thought its duration focusing on the detection of various objects/events/attributes: (i) visual and multispectral object detections including executed on embedded platforms, (ii) activity recognition via visual streams, (iii) CBRN detections and, (iv) cyber-threat identification.		
Related Project Objectives	PO.3: Improved AI-based cognitive models for optimal surveillance PO.4: Intelligence for prediction and coordinated response		

T6.1 Automatic object identification from visual spectrum (CERTH)

Overall progress and reporting

Task 6.1 focuses on the development of an AI-powered tool for automatic object detection from visual data streams, enhancing the security and operational awareness of CI environments. The detection model is designed to identify a broad spectrum of relevant objects, including humans, vehicles, environmental hazards (e.g., fallen debris, stones, smoke, fire), and potential threats.

A core objective of this task is to ensure the model's efficiency, reliability, and adaptability, particularly in resource-constrained environments. To achieve this, the model is optimized for deployment on edge devices, enabling real-time detection even in locations with limited computational resources.

The task has progressed by identifying key user requirements and defining relevant deployment scenarios. Research on deep learning models has been conducted to determine the most suitable approach, with a focus on efficiency and low-power algorithms for UAV platforms. The tool is capable of detecting different categories of objects and has achieved satisfactory average detection accuracy. Additionally, publicly available datasets have been evaluated to ensure alignment with the task's objectives. The progress of T6.1 activities is analytically described in D6.1.

Identified issues/deviations:

There are no significant deviations from the project's planned objectives at this stage. The implementation is progressing as expected.

T6.2 Multispectral scanning and detections (CERTH)

Overall progress and reporting

Task 6.2 is responsible for providing the project's platform with an IR/thermal object detection system. The spectrum on which the task modules operate is IR, which posed certain limitations for the smooth completion of the task, especially for the collection of training/evaluation data. Following the definition of the objects of interest, research for available public datasets was initiated. Unfortunately, the specific task is of marginal interest to the community, and thus, resulting in limited availability of such datasets. To address this, the compilation of a custom-made dataset was pursued, incorporating parts of multiple individual datasets, some of which were not intended for object detection but focused on related tasks

such as image classification (no annotation available) and tracking (partial annotation). To fully adapt to the requirements of the task, manual annotation, object pruning, and class merging were performed to create a dataset suitable for the project's requirements.

The next step involved the selection of an adequate model for thermal object detection, which included the training and evaluation of several state-of-the-art models. An extensive comparison between different architectures and models was performed to select the final model. During this process, the performance of different models in the IR was documented and is the main focus of a research paper currently being prepared for scientific publication in the near future. The trained models were tested against footage from CCTV cameras intended for use in UC2, and adaptations were implemented to improve the performance of the models based on the output of the footage material. Further actions in this direction are expected as more data become available. The advancements in T6.2 activities are comprehensively analysed in D6.1.

Identified issues/deviations

There are no significant deviations from the project's planned objectives at this stage. The implementation is progressing as expected.

T6.3 Visual object recognition on embedded devices (NTTD-IT)

Overall progress and reporting

The objective is to implement an AI inference engine on embedded systems to develop a software component designed to run an object detection algorithm. The software will be capable of identifying objects of interest from camera images. These embedded systems will be deployed on autonomous platforms (UxVs), to address the requirements for Use Case 2 and Use Case 3 of the project.

A few embedded platforms have been considered for T6.3 implementation. Currently, different libraries and deep learning frameworks have been studied and tested to efficiently run computer vision models on these low-power devices. Depending on the platform used, specific optimizations will be required to ensure optimal performance. The deliverable D6.2 outlines and analyses the developments in T6.3 activities.

Identified issues/deviations

There are no significant deviations from the project's planned objectives at this stage. The implementation is progressing as expected.

T6.4 Activity recognition models from video contents (VICOM)

Overall progress and reporting

The task focuses on recognizing multiple types of security-relevant events and threats, particularly related to human actions and adverse traffic situations. Considering the scarcity of data available for domain adaptation tasks of AI models, the initial activities were built around the generation of synthetic datasets that realistically reproduce the events of interest. A simulation framework utilizing Unreal and Beam NG engines was developed to create an initial dataset comprising five distinct scenarios related to normal and

anomalous traffic conditions. A publication on the methodology has been prepared and is currently undergoing a scientific review process.

Technology adaptation progressed as planned. The architecture of the action recognition model has been defined and a new training environment was implemented. The module incorporates an action-specific feature extractor and employs both supervised and unsupervised classification heads for the recognition of actions of interest. Currently, the feature extractor is being trained on public datasets containing real-world CCTV footage. This ongoing training process aims to establish a robust base model, which will later be adapted to the specific characteristics of the selected use case scenarios through transfer learning techniques. D6.1 offers a detailed analysis of the progress achieved in the task.

Identified issues/deviations

There are no significant deviations from the project's planned objectives at this stage. The implementation is progressing as expected.

T6.5 CBRN threat identification (T4i)

Overall progress and reporting

Significant progress has been made in upgrading the T4i DOVER, a system designed for detecting and identifying chemical compounds, in alignment with TESTUDO scope. The first prototypes of the built-in calibration module and the liquid sampler were designed and assembled. The first versions of the upgraded T4i DOVER chemical detector and the field vapour generator (FemtoMachine) were built, in order to meet and match TESTUDO requirements. Preliminary testing and evaluation of the built-in calibrator has been carried out, utilizing distinct chemical compounds—one for sample intake and another for calibration—while examining key parameters such as compound type/nature and concentration levels. Efforts to optimize alarm transmission of the upgraded T4i DOVER to the operational centre are ongoing, focusing on refining communication protocols for seamless integration.

Additionally, hardware improvements have been made to T4i DOVER PCBs, including the addition of soldered nuts and connectors to enhance modular support and system stability. Regarding field airborne deployment, the initial integration of T4i DOVER with the UAV provided by ACCELI has been successfully completed (in a lab/controlled environment), whilst a test flight plan has been agreed for performance evaluation, operational feedback and optimization.

To improve durability in extreme environments, the FemtoMachine casing is currently being redesigned to withstand harsh field conditions such as dust and water with an Ingress Protection (IP) certification under consideration. Preliminary environmental resistance tests have already been conducted, showcasing its resilience against harsh conditions. Test results are under evaluation to identify potential weak points and optimization pathway.

For water analysis, the development of an automated liquid sampler is underway, with initial 3D CAD designs and technical drafts completed. This system will enable automatic sample collection and direct introduction into a fixed DOVER detector, significantly improving efficiency in liquid-based chemical detection.

Progress of all activities is analytically described in D6.1. Built-in calibrator and liquid sampler designs and preliminary testing, PCB's and diagrams are EU RESTRICTED information and will be specified in D10.2.

Identified issues/deviations

There are no significant deviations from the project's planned objectives at this stage. The implementation is progressing as expected.

T6.6: Cyber threat identifications (CEA)

Overall progress and reporting

The objective of Task 6.6 is to develop an intrusion detection system (IDS) for monitoring the TESTUDO platform and detecting ongoing cyber threats. A first prototype of the IDS (named Sigmo-IDS) has been developed and adapted to the TESTUDO architecture. Sigmo-IDS can currently be deployed to network entry points to monitor network interfaces specified by the user. It can ingest, process, and analyse traffic in real time, producing alerts when anomalous traffic is detected. Predictions are based on an AI module, which learns statistical patterns of the regular/benign traffic in an unsupervised manner and uses them to identify anomalies. While the AI module is meant to be trained on the network traffic where it is deployed, tests have been conducted on public IDS testbeds to assess its accuracy in detecting cyber-attacks. The model architecture and calibration process were tuned to achieve high performance on ICS/SCADA use cases.

Additionally, when an alert is raised, the IDS automatically forwards it to other TESTUDO components through the TESTUDO message bus. One separate alert is sent for each anomalous/malicious connection, with minimal latency between the connection creation and the alert reception by other components. A preliminary UI has also been developed to visualize incoming connections and their respective anomaly scores in real time. D6.1 provides an analytical account of the progress made in T6.6 activities. Moreover, D8.2 documents the successful application of Sigmo-IDS within the UC1 scenario.

Identified issues/deviations

There are no significant deviations from the project's planned objectives at this stage. The implementation is progressing as expected.

Deliverables submitted

D6.1. "Cognitive intelligence for threat identification v1" - [VICOM, M18]

Progress per Project Objective

WP6 activities have contributed to the PO.3 and PO.4 advancement through the development and validation of advanced AI-based cognitive models for surveillance and intelligence-driven response systems. During the first period, WP6 established a strong foundation for further refinements and testing, ensuring progress toward improving CI protection through AI-driven solutions.

In relation to PO.3, WP6 developed innovative detection tools tailored to CI surveillance needs, including embedded platform variations. These tools use AI models for holistic detection, classification, and monitoring of suspicious objects, activities, and natural disasters. Modules were developed for visual

detection, multispectral detection, and low-power edge computing ensure real-time, high-accuracy threat detection across diverse data modalities, enhancing situational awareness and complementing existing surveillance systems. By integrating multi-spectral imaging, CBRN detection, and cyber-threat analysis, the developed modules enhance situational awareness and complement existing surveillance systems.

WP6 has advanced the development of AI-based solutions for detecting hazardous events, such as physical attacks and natural disasters, to support rapid and coordinated responses, thus contributing to PO.4. Action recognition modules that identify anomalous situations and safety threats from video streams can enable improved decision-making and coordinated responses in critical scenarios.

Risk Inventory

#	Description	Likelihood	Impact	Response
Risk 1	Publicly available object detection datasets may not cover all the real-world conditions.	Medium	Medium	Evaluate existing datasets and assess requirements for synthetic data.
Risk 2	Inadequate number of image samples for every class of interest for thermal detector.	Medium	Medium	Use multiple datasets and more extensive data augmentation.
Risk 3	Imbalanced datasets which pose potential difficulties in training a robust thermal detector.	Medium	Medium	Use class weights and more extensive data augmentation.
Risk 4	Uncommon data, poorly represented in public datasets, can be difficult to use for extensive training of algorithms.	Medium	Medium	Use multiple data sources and build a custom dataset or change the algorithm type to a simpler one.
Risk 5	Insufficient data to train the models for activity recognition - lower accuracy of the models trained on synthetic data.	Medium	Medium	Design a pipeline of simulations to cover more cases.
Risk 6	Models do not fulfil the requirements in terms of performances for embedded devices.	Medium	Medium	Use another model or smaller version of the main model.
Risk 7	False positives in IDS alerts.	Medium	Medium	Add whitelisting mechanism to the IDS UI.

Table 6. Risk Inventory for WP6

2.2.5. WP8 - Predictive intelligence, operational support and platform implementation v1

Leader	CENTRIC	**Contributors**	CERTH, ACCELI, STWS, NTTD-IT, CEA, ENG, PIAP, T4I, VICOM, DFKI, TEKN, DRAXIS, ADS, CENTRIC
Start month	January 2024	**End month**	March 2025
Objectives	This WP will develop a well-structured data model, fusion schemes, XAI based threat assessment, predictive models using Digital Twins, all integrated into one unique		

Leader	CENTRIC	**Contributors**	CERTH, ACCELI, STWS, NTTD-IT, CEA, ENG, PIAP, T4I, VICOM, DFKI, TEKN, DRAXIS, ADS, CENTRIC
	monitoring centre for advanced situational awareness. The monitoring centre will provide enhanced capabilities through novel HMIs using XR technologies.		
Related Project Objectives	PO.4: Intelligence for prediction and coordinated response PO.5: Increased situational awareness via novel HMI technologies		

T8.1 Multimodal fusion techniques to support monitoring systems (CENTRIC)

Overall progress and reporting

This module develops a flexible, interoperable multimodal fusion scheme to integrate diverse sensor data within the TESTUDO framework. It transforms structured sensor data (IDMEFv2) from various sources, including UXVs, visual, multispectral, thermal, LiDAR, and cybersecurity tools, into high-level alerts for improved decision-making and situational awareness.

An initial version of the fusion module was successfully used as part of the UC1 scenario and is reported in D8.2. Its role was to fuse the outputs from the network intrusion module IDS and then serve a fused output to the command centre. Development efforts have subsequently continued to enhance the module to support the UC2 scenario, including support for all new tools and develop fusion schemas that allow for logical fusion outputs to be generated. The module will also be integrated and supplemented by ENGs fusion tool to allow for more advanced and enhanced functionality. Analytical progress on T8.1 activities is described in D8.1.

Identified issues/deviations:

There are no significant deviations from the project's planned objectives at this stage. The implementation is progressing as expected.

T8.2 Explainable AI for threat assessment (VICOM)

Overall progress and reporting

The XAI tool is a module designed to detect evasion attacks in convolutional neural networks (CNNs) and multilayer perceptrons (MLPs) by analysing model behaviour through explainability methods. It generates a graph representation where nodes represent filters or neurons, and edges denote activations, illustrating how the model processes each input sample. Additionally, the XAI tool includes a visualization module that displays the masked behaviour graph, highlighting anomalous activations and enabling users to monitor and understand adversarial impacts on the model.

The primary focus during this period was the development of the first complete version of the tool. A scientific convolutional neural network environment was created using the MNIST dataset. Within this setup, a graph representation was implemented to visualize the behaviour of the CNN model. Next, a filtering method for the kernels in the convolutional network was introduced, allowing for targeted analysis. This step was crucial, as reducing the number of parameters for analysis made the detector in the XAI tool more manageable and scalable. Subsequently, the corrupted input detection system was developed based on the CNN's behaviour graph representation, utilizing graph neural networks as the

detection technology. Finally, the entire process was evaluated within the MNIST environment, yielding promising results. For this evaluation, corrupted images were generated from the MNIST dataset using three different evasion attack algorithms. Currently, the visualization module has been developed and integrated, though further testing is required before moving to the next stage.

In the upcoming phases, the goal is to integrate this XAI tool with the ActivityRecognition tool to enhance the security of the ANN model developed in TESTUDO. Additionally, new evaluation scenarios will be designed and implemented to validate and refine the XAI tool as needed. Progress in T8.2 activities has been thoroughly documented and analysed in D8.1.

Identified issues/deviations

There are no significant deviations from the project's planned objectives at this stage. The implementation is progressing as expected.

T8.3 Prediction models via Digital Twins (DTs) (CERTH)

Overall progress and reporting

The PredictionAnalysis tool has as objective to promote proactive awareness, enabling timely decision-making and intervention. The main focus during this period is pointing to Use Case 2 regarding the chemical fire in tunnel provoked by an electric car. The plan involves utilizing the PredictionAnalysis module to predict the upcoming fire severity level based on prior sensors observations. This is achieved through examining and analysing the available CO and Temperature sensors of the tunnel infrastructure. Based on the available sensors, a corresponding public dataset was utilized. This dataset was transformed into discrete time windows of length *t*, enabling the prediction of the fire severity class at the subsequent time step (*t+1*). After addressing class imbalance issues in the dataset, a specific type of a recurrent neural network model was trained for this purpose.

The current focus has shifted to collecting real-world data to improve model performance and enhance overall accuracy in alignment with KPI objectives. Additionally, an extensive evaluation is underway, benchmarking alternative models, methodologies and datasets to identify best practices for developing a stable, reliable and well-established solution. The deliverable D8.1 provides a detailed analysis of the progress achieved in T8.3.

Identified issues/deviations

There are no significant deviations from the project's planned objectives at this stage. The implementation is progressing as expected.

T8.4 Monitoring centre with improved HMI via DTs and XR technologies (STWS)

Overall progress and reporting

Progress towards achieving the objectives for T8.4, as far as the reporting period in consideration, required first laying the foundation for the TESTUDO monitoring centre. This task involved defining the project goals, identifying key milestones, and gathering the necessary resources. In this context, the components that will need to communicate with the monitoring centre were identified, ensuring that the monitoring infrastructure can integrate various streams of data and required functionality for smooth operation. As such, the component will act as a central hub for situational awareness by integrating data

from multiple sources and sensors, applying multimodal fusion techniques, and leveraging AI-driven threat prediction and prevention models.

Through Digital Twins (DTs) and Extended Reality (XR) technologies, the centre has been designed to provide an advanced 3D visualization environment that enhances decision-making at strategic, tactical, and operational levels with its architecture and interfaces being adapted within the context of TESTUDO to ensure seamless integration with other TESTUDO components. During the reporting period in consideration, this adaptation focused on refining the system's structure, enhancing interoperability, and aligning it with the project's overall framework. Additionally, the platform's functionalities are being extended to meet the specific user requirements of the TESTUDO project, ensuring it provides comprehensive situational awareness, improved decision support, and enhanced operational efficiency for all relevant stakeholders.

The current development stage of the Monitoring Centre targets the implementation of a new user interface (UI) and service design, which is currently under development. Finally, the Monitoring Centre successfully participated in the UC1 (integration test) and presented the cyber-attack detection data on the Operator's screen, as documented in D8.2.

The work completed on the XR component has included development of UI for manipulating 3D models representing the CI locations. Work has also been completed on functionality to add markers to the models to be displayed when alerts are received and to indicate the positions of UxVs. D8.1 analytically details the progress of activities undertaken in T8.4.

Identified issues/deviations

There are no significant deviations from the project's planned objectives at this stage. The implementation is progressing as expected.

T8.5 Platform development and integration (NTTD-IT)

Overall progress and reporting

Task 8.5 involved activities related to the the first version of TESTUDO platform release, needed to enable data exchanging between all TESTUDO tools. Key activities of this task were the UC1 integration tests, executed on a simulated network dataset. Through development and testing activities, modules Sigmo-IDS, Fusion tool and CSIM Dashboard were successfully integrated, laying the foundations to all other tools integrations.

CEA, STWS and CENTRIC each contributed to the activities for the tool they are responsible for. ENG contributed to define the format of data exchanged. TEK contributed to message bus development, testing and establishing VPN connections to the message bus. The deliverable D8.2 reports the activities of T8.4 for the deployment of first prototype of the envisaged platform.

Identified issues/deviations

There are no significant deviations from the project's planned objectives at this stage. The implementation is progressing as expected.

Deliverables submitted

- D8.1 “Models for predictive intelligence and fast response v1” - [CENTRIC, M18]
- D8.2 “First version of TESTUDO platform” - [NTTD-IT, M18]

Progress per Project Objective

This work package contributes to the achievement of the project objectives, PO.4 Intelligence for prediction and coordinated response, and PO.5 Increased situational awareness via novel HMI technologies.

During the reporting period, WP8 has worked at enhancing intelligence for prediction and coordinated response (PO.4) by ensuring that diverse information is structured for effective analysis, enabling predictive modelling and early threat detection through standardising data representation. This was showcased through the execution of the fusion module in UC1. Progress toward this PO will continue in the UC2 and UC3 phases through the continued development of these modules whilst additionally utilising the Prediction Analysis module to predict the upcoming fire severity level based on prior sensors observations and integrating the XAI tool with the ActivityRecognition tool to enhance the security of the ANN model developed in TESTUDO.

During the reporting period, WP8 has laid a solid foundation for enhancing situational awareness by developing innovative HMI technologies (PO.5). This is through (a) the Monitoring Centre, serving as the central platform where threat intelligence, simulation models, and real-time alerts are processed and visualised, enabling operators to react efficiently to potential threats, and (b) by ensuring that human-machine interfaces can process and present integrated, real-time data in a clear and actionable manner through the data fusion module. This was showcased through the execution of these modules in UC1. Progress toward this PO will continue in the UC2 and UC3 phases with the integration of XR technologies into the Monitoring Platform, as well as the development of an interface for real-time monitoring of AI model behaviours during inference, enabling the detection of corrupted behaviours in targeted artificial neural networks caused by malicious inputs. Additionally, the Prediction Analysis module will ensure the delivery of clear, interpretable, and timely alerts, enabling responders to quickly grasp impending risks and take appropriate action.

Risk Inventory

#	Description	Likelihood	Impact	Response
Risk 1	Lots of integration efforts are required to gather the needed data and output it to other relevant parts of the solution.	Medium	Medium	Ensure a high level of communication is present so issues can be quickly identified and resolved when integration is taking place.
Risk 2	Bad results in the functionality of the filtering method of the XAI tool	Low	High	Ensure that it works correctly in a different AI environment. Another alternative is available in case bad results are received.
Risk 3	Imbalanced datasets, which pose potential difficulties in model training.	Medium	Medium	Use multiple datasets, more extensive data augmentation.
Risk 4	The effectiveness of the CO sensors might be affected by	High	High	Select different sensors or integrate additional sensors

	their placement and distance from the incident source			
Risk 5	XR application will need to convert the 3d models acquired to a format that is usable with acceptable framerate on the XR device.	Medium	Medium	Testing various types of conversion software to create a model that is usable.
Risk 6	Technology integration complexity and compatibility issues with interfacing components of the monitoring centre.	Medium	Medium	Conduct interoperability testing, establish a technical working group, and adjust technical project specifications as necessary.
Risk 7	Inadequate identification of technology gaps leading to potential operational deficiencies.	Low	High	Establish a continuous review mechanism for technology requirements and engage in ongoing dialogue with component providers.
Risk 8	Integration complexity as technical modules progress from specifications to implementation stages, requiring adjustments.	Medium	Medium	Validation process at each development stage, flexible project timeline, and continuous stakeholder communication.

Table 7. Risk Inventory for WP8

2.2.6. WP11 - Impact creation and outreach v1

Leader	DBC	**Contributors**	CERTH, ACCELI, STWS, NTTD-IT, EYDAP, CEA, ENG, PIAP, T4I, PROS, VICOM, SINTEF, DFKI, INTER, TEKN, DRAXIS, ADS, LIF, DBC, CENTRIC
Start month	October 2023	**End month**	March 2025
Objectives	This WP aims to: (i) design a communication and dissemination strategy to promote the project's results, (ii) define an exploitation plan and verify the exploitation potential, (iii) engage stakeholders and identify collaborations with other relevant projects, (iv) provide policy recommendations and an overall project impact assessment.		
Related Project Objectives	PO.7: Identification of potential uptakes and impacts		

T11.1. Dissemination plan, toolkit and actions (PIAP)

Overall progress and reporting

The role of this task was to update and implement the dissemination plan for communicating and promoting the project and its findings. Between M01 and M18, the following actions were performed in T11.1:

- The professional visual identity was created, covering the project logo, templates for presentations, and other materials.

- The project's public website was launched, which included general information about the project, its objectives, and partners, as well as other material that was generally distributed, with further refinements in terms of appearance, content, and functionalities (including implementation of the newsletter subscription service).
- The project's social media accounts (x.com (former Twitter), LinkedIn) were launched, which included updates about the most important news and events related to the project.
- The project's communication materials were created, encompassing:
    - An introductory video that presented an overview of the project goals and ambition, published via the project website and made available for partners to use on various occasions (e.g., to be displayed at an exhibition/fair stand).
    - A general project presentation with basic information and a variety of templates for different slides that might be used on various occasions or serve as a basis for partners' own presentations according to their needs.
    - Advertising materials of high quality and in a standardized format (including digital versions for online release and self-print as well as professional print-outs), i.e., project leaflet, poster, and roll-up to be used/distributed at meetings and events.
    - Another dissemination video, explaining project objectives and goals has been prepared, to emphasize the scientific and practical benefits resulting straight from the outcomes of the project. At the time of writing, the video should be considered as pre-final. After final consultations and SAB review, it should be published.
- The communication & dissemination activities collector sheet was prepared and managed to serve better coordination and reporting of the various communication and dissemination efforts of different partners.
- Several communication and dissemination activities were performed by project partners, such as:
    - Presentation/attendance at large events (with distribution of leaflets) (VERIFIN international workshop on Chemical Warfare Agents, AR Expo24 1st Automations & Robotics Expo; XII International Scientific Conference HEMUS 2024; Eurosatory 2024 exhibition; Scientific Session "Modern aspects of security – Challenges, Approaches, Solutions", organized by the Faculty "Command and Staff" of the National Defence College of Bulgaria; 32nd International Defence Industry Exhibition MSPO).
    - Presentation/attendance at workshops/seminars/webinars/meetings (Projects to Policy Seminar (PPS); EU-CIP & ECSCI Webinar: "The Double-Edged Sword of AI in CIP"; NTT DATA meeting with University of Sapienza representatives).
    - Online activities (e.g., social media posts on the project and individual partners' channels, presentations, and news items on partners' websites).
    - Liaison with other initiatives – joining and active participation in the European Cluster for Securing Critical Infrastructures communication and events.
    - Preparation of the TESTUDO demo corner/showroom at NTT DATA Milan office – an established space dedicated to providing an experience for NTT Data visitors, serving as a platform for showcasing demonstrations tailored for esteemed profiles such as clients, teams, and sector professionals.

- Preparation of the first issue of the project newsletter.
- Communication materials were delivered, reporting the dissemination plan and the materials to be used for these plans, including contributions from tasks T11.2 and T11.5.

Deliverables D11.1 and D11.2 contain a detailed account of the activities performed in T11.1.

Identified issues/deviations

The project activity is progressing as planned, with no significant deviations from the expected objectives to be reported at this stage. D11.1 was submitted in M7 due to the efforts for the refinement of the dissemination toolkit.

T11.2. Standardization activities and development of stakeholder network (T4i)

Overall progress and reporting

T4i has led the development of the Stakeholders' Community, conducting a stakeholder mapping exercise in collaboration with project partners to identify and categorize key actors. Informational material and invitations have been structured based on stakeholders' professional backgrounds, ensuring targeted outreach. A table has been created to align stakeholders with relevant activities, serving as a reference throughout the project's duration. T4i also developed a targeted email campaign, in collaboration with LIF, incorporating best practices in data protection and user rights. Initial engagement began with outreach to water supply and sewage services through general service addresses to ensure compliance with data protection regulations. The next steps include tracking responses, sending follow-ups, and organizing introductory webinars to engage stakeholders and encourage participation. The deliverable D11.2 provides an analytical overview of the progress in relation to T11.2 tasks.

Identified issues/deviations

The project activity is progressing as planned, with no significant deviations from the expected objectives to be reported at this stage.

T11.3. Market analysis and potential business models (ACCELI)

Overall progress and reporting

ACCELI has carried out an initial in-depth market analysis (T11.3, M01-M18) for the TESTUDO project. As part of this effort, a partners' fill-in form and a list of technologies were distributed to the technical partners to gather information on each technology's contribution to the project. This process includes identifying the assets and contributions of the partners that will be part of the TESTUDO solution. ACCELI has gathered all the necessary inputs from the technical partners and has analysed the data. As part of the market analysis, a SWOT analysis was conducted, and the business environment in which the TESTUDO project will operate was identified. Additionally, the benefits that TESTUDO will offer to the industry and market players were outlined. A policy plan and regulatory framework analysis was also prepared. Currently, ACCELI is developing the Business Model Canvas (BMC), a strategic management tool that details the key activities, resources, goals, and objectives of the TESTUDO project. ACCELI is also working to identify the technology trends associated with each exploitable asset of the TESTUDO project. The efforts and results from T11.3 activities are documented in detail in Deliverable D11.3.

Identified issues/deviations

The project activity is progressing as planned, with no significant deviations from the expected objectives to be reported at this stage.

T11.4. Exploitation strategies and long-term sustainability (DBC)

Overall progress and reporting

Significant progress was made in the second semester (M7-M12) towards defining the exploitation strategy for the TESTUDO project. One of the key achievements was the creation of the Exploitation Tool, an online Excel-based platform developed by DBC to facilitate collaborative input collection on potential exploitable results. This dynamic tool enables real-time updates from all partners. In addition, partners were requested to provide their initial input by identifying exploitable results, including both the originally defined exploitable outcomes from the project proposal and any new suggestions emerging during the project. Each partner was responsible for describing the exploitable results they identified, forming the foundation for further evaluation. Once all partners submitted their input, an evaluation process was initiated to determine which results could be classified as Key Exploitable Results (KERs), considering both technical feasibility and market potential. Partners identified 20 Exploitable Results, which were subsequently analysed and incorporated into Deliverable D11.3. Initial individual exploitation plans were drafted, with updates planned for the second reporting period. These activities mark a significant step in the exploitation strategy development, setting the groundwork for refining the identified results and finalizing individual exploitation plans in the upcoming reporting period, as documented in D11.3.

Identified issues/deviations

The project activity is progressing as planned, with no significant deviations from the expected objectives to be reported at this stage.

T11.5. Impact in EU policy for critical infrastructure protection (DBC)

Overall progress and reporting

Task T11.5 began with preliminary planning, including registering initial activities in Deliverable D11.1. Progress accelerated with strategic engagement initiatives, such as TESTUDO's participation in the 2024 Projects to Policy Seminar in Brussels on 25-26 June 2024, organized by the European Research Executive Agency (REA) and the Directorate-General for Migration and Home Affairs (DG HOME). This event provided a platform to engage with EU policymakers, align project objectives CIP policies, and gain insights into policy priorities and expectations. Following this, DBC led key preparatory actions to translate project findings into policy recommendations. A stakeholder mapping process identified organizations and key individuals in the policy-making landscape, ensuring targeted engagement. The TESTUDO project also participated in the "Fortifying the Future" webinar on 10 December 2024, organized by the ATLANTIS project, EU-CIP, and the ECSCI Cluster. With over 100 attendees, including policymakers, industry experts, and researchers, the event facilitated discussions on strengthening CI resilience against emerging threats, reinforcing TESTUDO's role in shaping EU policies and standards. In parallel, a structured methodology for policy briefs was established, ensuring that project insights are effectively translated into actionable recommendations. These briefs align with EU priorities such as the EU Security Union Strategy (2020-

2025), Directive (EU) 2022/2557 on critical entity resilience, and GDPR compliance. Dissemination efforts, including workshops, advisory board meetings, and targeted publications, will maximize the reach and impact of these findings. The first policy brief was finalized in March 2025 and distributed to key policy stakeholders, marking a crucial step in bridging TESTUDO's outcomes with EU policy development. D11.2 provides an analytical account of the progress in T11.5.

Identified issues/deviations

The project activity is progressing as planned, with no significant deviations from the expected objectives to be reported at this stage.

Deliverables submitted

- D11.1 "Dissemination plan and communication materials" - [PIAP, M07]
- D11.2 "Activity report on dissemination activities and policy making" [DBC, M18]
- D11.3 "Exploitation plans and impact pathways assessment" - [DBC, M18]

Progress per Project Objective

The activities carried out under WP11 have significantly contributed to achieving PO7: Identification of potential uptakes and impacts by planning and ensuring effective communication, dissemination, and engagement with key stakeholders. Through structured outreach efforts, WP11 has facilitated the visibility of the TESTUDO project, enhancing stakeholder awareness and fostering collaboration. The targeted dissemination efforts have ensured that TESTUDO's innovations reach the relevant audiences, supporting knowledge transfer and maximizing societal and technological benefits.

Risk Inventory

#	Description	Likelihood	Impact	Response
Risk 1	T11.3 – partners do not give input (on time)	High	High	Contact with the WP leader.
Risk 2	T11.2 - Difficulty in engaging with stakeholders external to the TESTUDO consortium	High	Medium	Collaborate with consortium partners who have extensive coverage across all or most types of stakeholders.
Risk 3	T11.4 - Lack of partner engagement	Medium	High	Set clear timelines and deadlines for partners to provide input. Organize workshops or one on-one meetings to ensure partners understand the importance of their contributions. Regular follow-ups and automated reminders via the online exploitation tool to keep partners engaged. Provide guidance materials to make it easier for partners to input relevant data.

Risk 4	T11.5 - Changes in EU policy landscape	Medium	High	Ensure continuous monitoring of EU policy developments throughout the project. Maintain close communication with key policy stakeholders. Be flexible and adapt the recommendations based on the latest policy trends, including mid-project adjustments where necessary. Regularly engage with policy events and working groups to align with current policy discussions.
Risk 5	T11.1 - Failure to reach KPI related to publications	High	Medium	Reminding and encouraging technical partners to disseminate their results via publications and conferences participation, strong internal communication about dissemination opportunities.

Table 8. Risk Inventory for WP11

2.3. Active work packages

2.3.1. WP10 - Large-scale pilot execution and evaluation

Leader	EYDAP	**Contributors**	CERTH, ACCELI, STWS, NTTD-IT, EYDAP, CEA, ENG, PIAP, T4I, PROS, VICOM, SINTEF, DFKI, INTER, TEKN, DRAXIS, ADS, CENTRIC
Start month	November 2024	**End month**	September 2026
Objectives	This WP aims (i) to evaluate the effectiveness of the proposed technological solutions by testing and fine-tuning them in line with the CI operators' needs, and (ii) to train end users in the consortium on the use of the new technologies. To this end, (iii) the pilot tests will be appropriately planned and prepared to execute the foreseen pilot use cases.		
Related Project Objectives	PO.6: Large-scale and cross-sectorial demonstrators		

T10.1 – Evaluation roadmap and methodology (DRAXIS)

Overall progress and reporting

Regular meetings were conducted with PROS given the strong connection between Task T10.1 and Task 10.4 to ensure alignment and collaboration. These discussions facilitated a coordinated approach, ensuring that the evaluation and validation methodology are well-integrated across pilot cases. Also, DRAXIS designed and distributed a qualitative questionnaire to technical providers. This initiative aimed to gather insights into the usage and applicability of each component within the project's use cases. The collected data is now being analysed using specialized analytical tools to extract key findings that will inform the evaluation process.

Furthermore, a preliminary evaluation procedure was drafted for the pilot case execution. This document outlines the assessment criteria and methodologies that will be employed to evaluate the effectiveness and impact of the pilot implementations.

Future steps

The next steps for Task T10.1 will focus on finalizing the evaluation methodology by incorporating insights from the ongoing analysis of the qualitative questionnaires. The drafted evaluation procedure will be refined for the pilot case execution, ensuring it aligns with the overall project objectives and KPIs. Also, follow-up discussions with technical providers and interviews with pilots' participants will be set up to validate our findings and address any gaps. T10.1, with the support of T10.4, will deliver D10.2: "Evaluation Methodology and Trial Validations" lead by DRAXIS by M36 (September 2026).

Identified issues/deviations:

No deviations from the project's planned objectives, as outlined in Annex 1 of the GA.

T10.2 – Chemical fire in cross-border tunnel (INTER)

Overall progress and reporting

Over the past months, INTER, as the leader of Task 10.2, has been coordinating efforts to prepare for the execution of the second TESTUDO pilot use case. While the task is scheduled to begin in April 2025, preparatory activities have been ongoing to ensure a well-structured and effective implementation.

The definition of UC2 has been informed by extensive discussions within WP3, where the specific requirements, scenario design, and next steps were outlined in collaboration with all relevant partners. INTER has played a key role in these discussions, contributing to the refinement of the scenario and ensuring alignment with real-world operational needs. Additionally, a site visit was coordinated by INTER in May 2024, allowing partners to familiarize themselves with the physical environment where the final trials will take place.

To facilitate the planning and execution of the demonstration, INTER has been organizing dedicated UC2 meetings, under the umbrella of WP10, which commenced in March 2025 and will continue on a weekly or biweekly basis, depending on the needs and progress of the task. These meetings have been instrumental in specifying the trial setup, technical requirements, and operational procedures. A crucial aspect still under discussion is the selection of the exact physical space for the demonstration, with three potential locations under consideration. The final decision will be made based on feasibility, logistical constraints, and technological integration requirements.

In preparation for the trial, INTER has structured its planning around three key resource categories:

- Tunnel resources: The available infrastructure has been assessed, including connectivity, surveillance systems, and other relevant operational assets. Discussions are ongoing to determine the level of access partners will have to these systems during testing.
- Drill resources: Initial considerations regarding the deployment of equipment and vehicles have been made, pending final decisions from the involved partners on their specific technological setups. The coordination of emergency response elements is also under review.
- Logistical resources: Accommodation, transportation, and operational facilities for the participating teams are being planned to ensure smooth execution during the testing period.

Further discussions with project partners will refine the timeline and finalize outstanding decisions to ensure all necessary elements are in place before execution.

Future Steps

- Finalize the selection of the demonstration site based on feasibility and operational requirements.
- Determine the exact dates for testing and trials within the confirmed five-night closure window between October and November 2025, allocating two nights for preliminary tests and three for final trials.
- Continue weekly/biweekly meetings to finalize technical and logistical details.
- Clarify access and use of tunnel resources to ensure smooth integration of technologies during the trials.
- The results of the trials will be outlined in D10.1 "Report on trials' execution and user training sessions", led by EYDAP, by M36 (September 2026).

Identified issues/deviations

No deviations from the project's planned objectives, as outlined in Annex 1 of the GA.

T10.3 – Large scale trial for water management facilities (EYDAP)

Overall progress and reporting

Task T10.3 is officially set to begin in October 2025 (M24) as part of the third year of the project. However, preparatory work has already started to ensure a smooth and efficient execution once the task is officially launched. One of the primary preparatory activities has been the identification and clarification of risks related to UC3, recognizing that risk management is a critical aspect of the task.

As part of this process, a list of unforeseen risks has been compiled, focusing on challenges that were not initially accounted for in the project's Grant Agreement. This effort ensures that the necessary mitigation measures are in place and that responsibilities for risk management are clearly assigned.

Finally, T4i has been actively engaged in preliminary discussions, aligning its technological developments with the identified needs of this trial. Specifically, the chemical detection and sampling solutions have been designed based on prior discussions with EYDAP, which defined the specific detection requirements and the available infrastructure (e.g., laboratory facilities, water tanks). This ensures that when the trial begins, the technology will be well-prepared for seamless integration into the planned water contamination detection scenarios.

Future Steps

The next steps for T10.3 will focus on finalizing the risk management strategy for UC3 before pilot execution begins. Specifically:

- Risk 6 as defined in Table 9: A deeper assessment is underway to determine how UC3 should address this risk and minimize its potential impact.
- Refining mitigation strategies – Defining concrete actions, identifying responsible partners, and establishing clear procedures to address each identified risk.

By the end of the trials EYDAP with the contribution of the T10.3 will deliver D10.1: “Report on trials’ execution and user training sessions” by M36 (September 2026).

Identified issues/deviations

No deviations from the project's planned objectives, as outlined in Annex 1 of the GA.

T10.4. Platform validation and user evaluation (PROS)

Overall progress and reporting

The task has progressed in parallel with T10.1 ‘Evaluation roadmap and methodology’. Throughout the period since the task was initiated, regular meetings have been held between T10.1 and T10.4 to coordinate the evaluation and validation process.

Under T10.4, the project’s KPI list that was designed under T3.2 has been expanded and enriched. For that, input from all technical partners has been requested and collected. This has been the focus of the first steps of the task, supporting T10.1 and preparing the foundations for evaluation across the three development circles of TESTUDO.

The second focus of the task has been preparing for the evaluation of UC1, which will follow the guidelines determined by T10.1 while also providing user input for the final version of the roadmap and methodology being developed. Data from technical partners developing the modules relevant to the operational test (UC1) has been requested for this reason and is to be analysed according to the methodology proposed.

Future Steps

Next steps in the upcoming two months are to analyse the input provided by UC1 technical partners and perform the evaluation and validation of the prototype, completing the first development circle and achieving Milestone 4; and completing the final list of KPIs, which will guide the validation process alongside the roadmap, designed under T10.1. Furthermore, preparations for the evaluation of UC2 will start once the evaluation roadmap has been finalised. T10.4 will contribute to D10.2: “Evaluation Methodology and Trial Validations” lead by DRAXIS by M36 (September 2026).

Identified issues/deviations

No deviations from the project's planned objectives, as outlined in Annex 1 of the GA.

T10.5 – User training and innovative curricula (DFKI)

Overall progress and reporting

This task started in February 2025, so it was not active for most of the current review period. However, a first draft plan for the implementation of the user training measures was developed.

Future Steps

The training plan foresees two pathways for the distribution of user training:

- Physical hands-on trainings
- Online webinars

The physical trainings will be organized during the two field trials and demos planned for UC2 and UC3., taking advantage of the onsite use of the TESTUDO system and all participating robots, thus enabling a direct interaction of the trainees with the systems. The target audience for the physical trainings will be local first responders and employees of the involved CIs. The trainings will cover a theoretical introduction in the TESTUDO project and system as well as hands-on demonstrations of the involved software tools and robots. The trainings will be performed in the local languages.

An online webinar will be offered between the two physical trainings, including a more general view of the current state-of-the-art of automated security systems and robotics. In addition, the webinar will feature technical solutions provided by TESTUDO partners. By the end of the trials, EYDAP with the contribution of the T10.5 will deliver D10.1: "Report on trials' execution and user training sessions" by M36 - (September 2026).

Identified issues/deviations

No deviations from the project's planned objectives, as outlined in Annex 1 of the GA.

Planned Deliverables

- D10.1 "Report on trials' execution and user training sessions" – [EYDAP, M36]
- D10.2 "Evaluation Methodology and Trial Validations" - [DRAXIS, M36]

Progress per Project Objective

The activities conducted within WP10, particularly through T10.1 (Evaluation Roadmap and Methodology) and T10.4 (Validation and User Evaluation), have been essential in defining structured methodologies for assessment, ensuring that the prototypes are rigorously tested across different scenarios and conditions.

One of the key contributions is the co-creation of use case scenarios, which has been carried out in collaboration with stakeholders via group work sessions and workshops. This ensures that the solutions are designed to seamlessly integrate with current operational workflows and address real-world security challenges. Moreover, WP10 has established working groups focused on specific tasks (Evaluation, UC2, UC3), ensuring that each aspect of the large-scale demonstrations is thoroughly examined and fine-tuned.

Additionally, WP10 has facilitated the development of a KPI-driven evaluation framework that enables the structured measurement of system performance, user satisfaction, and operational efficiency. The alignment with KR18 (Pilot use cases and user requirements), KR19 (Iterative user evaluations), and KR20 (End-user training material) is evident in the continuous feedback loops and validation processes incorporated into the development cycles.

The upcoming trial phases will further escalate the deployment complexity, gradually expanding from partial system integration to full-scale demonstrators, ensuring that the final solutions are robust, effective, and adaptable across different CI environments.

Risk Inventory

#	Description	Likelihood	Impact	Response
Risk 1	Issues between the new technological solutions and existing infrastructure of CIs.	Medium	Medium	Technology providers and end users must discuss and resolve any issues before the start of T10.2 and T10.3. Start the organisation of the aforementioned Tasks earlier.
Risk 2	CI operators might be resistant to adopting new technologies	Medium	Low	Consider why they might be resistant and drive (technology providers and UCs) the UCs through the solution
Risk 3	Environmental conditions could impact the pilot tests.	Low	Low	Consider these conditions for each UC. What could influence the tests in respect to the environmental conditions?
Risk 4	No contamination can be performed in the water reservoir or the water tanks of the DWTP, thus no abnormalities could be shown in the SCADA systems and some TESTUDO technologies could not be tested.	High	High	Contamination can be performed in an external small tank.
Risk 5	No access into the SCADA systems or other internet systems of the CIs.	Low	High	Check the SCADA possibilities of other locations.
Risk 6	UAVs cannot be utilized without prior permissions by the national authorities due to aerial restrictions.	Medium	Medium	Get the necessary permissions timely.
Risk 7	Need for confidentiality regarding the locations, assumptions and goals of the TESTUDO use cases may impact the training programme.	High	Medium	Carefully select both the audiences and the content of the training programme.
Risk 8	Not possible to operate the UxVs efficiently due to the risk of injuring people.	Medium	Medium / High	Work on the detailed step-by-step scenario description to clarify the necessary presence of people when the robots are operating, during the pilot execution.
Risk 9	Difficulties in integration of software and hardware components to the UAVs and UGVs	Medium	Medium / High	Conduct early integration testing using prototypes to identify and resolve compatibility issues at an early stage, provide detailed and consistent documentation for all software components to facilitate understanding and implementation, use simulation environments or emulators to test software integration before deployment on physical UAVs and UGVs. Collaboration and Communication between partners

Table 9. Risk Inventory for WP10

2.4. Upcoming Work Packages

2.4.1. WP2 - Project Management and Coordination v2

Leader	CERTH	**Contributors**	CERTH, ACCELI, STWS, NTTD-IT, EYDAP, CEA, ENG, PIAP, T4I, PROS, VICOM, SINTEF, DFKI, INTER, TEKN, DRAXIS, ADS, LIF, DBC, CENTRIC
Start month	April 2025	**End month**	September 2026
Objectives	The main objectives of the WP are to: (i) to provide overall project management and coordination; (ii) interface between partners and relevant external stakeholders; (iii) monitor, track and control quality as well as risks and deviations due to progress, cost, financial and planning changes; (iv) develop the data and IPR management plan; and (v) monitor the security, ethical, legal, and privacy management for the whole duration.		
Related Project Objectives	There are no POs related to WP2 objectives and content.		

The efforts in relation to T2.1 and T2.2 will continue as foreseen, according to the project timeline. The third TESTUDO plenary meeting will be organized in Vilnius, Lithuania at the beginning of the second period, with additional plenary meetings to follow based on the overall timeline. Coordinated efforts on scientific and technical management will ensure the successful planning and execution of UC2 and UC3 and the respective technical quality of activities for D5.1, D7.1, D9.1 and D9.2. An online Workshop on Core Ethical Aspects in Research Activities is currently under preparation within T2.5 and is scheduled to take place in April 2025. Future workshops will be organised to facilitate partners' training in connection with activities contributing to D2.1 "Security, ethics, legal, IPR management and final data management plan".

2.4.2. WP5 - Augmented sensing and communications for effective autonomy v2

Leader	ENG	**Contributors**	CERTH, ACCELI, NTTD-IT, CEA, ENG, PIAP, T4I, PROS, SINTEF, DFKI, INTER, TEKN, DRAXIS, ADS
Start month	April 2025	**End month**	June 2026
Objectives	The WP has the following development objectives: (i) design and develop a secure network of communication for the involved assets, (ii) define the sensors used for optimal monitoring of the CIs, (iii) develop robust/ secure coordination of all the autonomous edge devices for optimal coverage, (iv) develop mission definition models for commanding the available assets, (v) develop 3D representation models for increased synergy with the DTs and XR technologies.		
Related Project Objectives	PO.1: Synergetic operations of unmanned assets and fixed resources for autonomous surveillance PO.2: Secure and efficient telecom networks for remote areas and interoperable devices		

WP5 activities will be all focused on development and testing all the functionalities already designed and described in WP4. These activities will be carried out in parallel with the use cases implementations and the activities of WP10, ensuring a coordinated approach across the work packages.

The primary goal of this work package is to create a secure communication network that will allow efficient interaction between the involved assets, while also defining the most suitable sensors for optimal monitoring of the systems. The development efforts will also aim to establish robust and secure coordination for all the autonomous edge devices, ensuring full coverage and system reliability. Moreover, the team will focus on defining models for mission commands, enabling precise control of the available assets. Lastly, the work will include the creation of 3D models to enhance integration with digital twins and extended reality technologies, promoting better synergy and a more immersive user experience. The activities from this period will be documented in D5.1 "Augmented sensing and communications v2".

2.4.3. WP7 - Artificial cognitive intelligence for threat identification v2

Leader	CERTH	**Contributors**	CERTH, ACCELI, STWS, NTTD-IT, CEA, ENG, PIAP, T4I, VICOM, DFKI, TEKN, CENTRIC
Start month	April 2025	**End month**	June 2026
Objectives	The WP has the following technical objectives thought its duration focusing on the detection of various objects/events/attributes: (i) visual and multispectral object detections including executed on embedded platforms, (ii) activity recognition via visual streams, (iii) CBRN detections and, (iv) cyber-threat identification.		
Related Project Objectives	PO.3: Improved AI-based cognitive models for optimal surveillance PO.4: Intelligence for prediction and coordinated response		

For the next period, T7.1 will focus on integrating the VisDetect Tool into the TESTUDO system and validating it with additional data to ensure reliability. Continuous improvements will be made, enhancing performance and detection accuracy. T7.2 efforts will include integration activities within the project's pipeline, potential improvements in the model's effectiveness and efficiency, and compiling the research conducted so far into a research paper. T7.3 activities will focus on software implementation, selecting reliable dataset sources, training detection models, and adapting execution for deployment on dedicated computing hardware, designed to operate efficiently on robotic devices for real-time environmental processing and analysis during field trials. T7.4 will concentrate on adapting and validating the trained models using newly generated simulation data. The models will then be integrated into the overall TESTUDO platform, ensuring proper data exchange formats and a real-time analysis pipeline. T7.5 next steps will involve finalizing technological advancements, enhancing system integration, and improving operational reliability, while ensuring adaptability to real-world conditions. Finally, planned work for T7.6 includes implementing end-user requirements, such as developing a more mature GUI for IDS management, integrating a logging system to monitor user activity, enabling periodic report generation. All tasks will conduct further testing to ensure model accuracy for TESTUDO UC2 and UC3, and use D3.2 and D3.3 as guides through all development activities. D7.1 "Cognitive intelligence for threat identification v2" will outline and analyse the activities from the WP7 tasks.

2.4.4. WP9 - Predictive intelligence, operational support and platform implementation v2

Leader	CENTRIC	**Contributors**	CERTH, ACCELI, STWS, NTTD-IT, CEA, ENG, PIAP, T4I, VICOM, DFKI, TEKN, DRAXIS, ADS, CENTRIC
Start month	April 2025	**End month**	July 2026

Leader	CENTRIC	Contributors	CERTH, ACCELI, STWS, NTTD-IT, CEA, ENG, PIAP, T4I, VICOM, DFKI, TEKN, DRAXIS, ADS, CENTRIC
Objectives	This WP will develop a well-structured data model, fusion schemes, XAI based threat assessment, predictive models using Digital Twins, all integrated into one unique monitoring centre for advanced situational awareness. The monitoring centre will provide enhanced capabilities through novel HMIs using XR technologies.		
Related Project Objectives	PO.4: Intelligence for prediction and coordinated response PO.5: Increased situational awareness via novel HMI technologies		

Development will focus on refining and extending functionalities, achieving full integration with the TESTUDO platform, and preparing the tools for operational use. Specifically, the next period of WP9 will focus on evolving tools that have proven their individual functionality in UC1 to be fully integrated into the TESTUDO platform via the interoperable data model developed by WP4 and ingest/display real data from the sensor and drone feeds used in the latter UCs. This coupled with the incorporation of additional feedback gathered during pilot phases will improve tool usability and effectiveness. Tools that were not used in UC1 will begin their integration with the platform in time for UC2, with full integration and functionality planned for UC3. Additionally, further work will be undertaken to ensure compliance with all relevant policies and laws such as GDPR and the EU AI Act before deployment. This will be done through the self-assessment tool provided by LIF in WP2 and WP3 as well as guidance from the deliverables D3.1 "Risk assessments" and D3.4 "Legal and ethical framework of TESTUDO". D9.1 "Models for predictive intelligence and fast response v2" and D9.2 "Final version of the TESTUDO platform" will provide an analytical review of the activities undertaken in WP9.

2.4.5. WP12 - Impact creation and outreach v2

Leader	DBC	Contributors	CERTH, ACCELI, STWS, NTTD-IT, EYDAP, CEA, ENG, PIAP, T4I, PROS, VICOM, SINTEF, DFKI, INTER, TEKN, DRAXIS, ADS, LIF, DBC, CENTRIC
Start month	April 2025	End month	September 2026
Objectives	This WP aims to: (i) design a communication and dissemination strategy to promote the project's results, (ii) define an exploitation plan and verify the exploitation potential, (iii) engage stakeholders and identify collaborations with other relevant projects, (iv) provide policy recommendations and an overall project impact assessment.		
Related Project Objectives	PO.7: Identification of potential uptakes and impacts		

During Task T12.1, PIAP will consistently continue to compile the dissemination results of the partners, sharing information through the project website and social media platforms. Special attention will be given to gathering information on partners' activities, including publications, participation in conferences, or other events that enhance public awareness. Additional dissemination materials may be created as the project progresses. The upcoming steps for T12.2, led by T4i, will focus on expanding stakeholder engagement by fostering direct interactions, enhancing outreach efforts, and refining communication strategies based on initial feedback to ensure meaningful and sustained collaboration. Regarding T12.3, ACCELI is developing the Business Model Canvas (BMC), a strategic management tool that details the key

activities, resources, goals, and objectives of the TESTUDO project. ACCELI is also working to identify the technology trends associated with each exploitable asset of the project. In the framework of T12.4 the finalization of the identified ERs will take place, with all partners assessing them using the exploitation tool. This assessment will determine the Key Exploitable Results (KERs). The process will be carried out within spring 2025. In the second reporting period, these KERs will serve as the foundation for developing business cases for the finalized results. Finally, DBC is committed to ensuring Task 12.5's insights lead to tangible policy impacts through a multifaceted engagement strategy. This includes among others policy briefs, collaboration with EU networks, digital outreach, and advisory board input to effectively communicate findings, refine recommendations, and influence decision-making. D12.1 "Final activity report on dissemination and exploitation activities" and D12.2 "Market analysis, final impact assessment and policy recommendations" will present a detailed account of WP12 activities.

3. Conclusions

The TESTUDO project has made significant progress during the first 18 months, aligning closely with the DoA timeline. While five deliverables experienced minor delays, these were effectively managed without affecting overall project objectives. All other deliverables of this period were submitted on time, and four milestones have been successfully achieved. Collaboration among partners has been efficient, with no significant issues identified.

WP1 (Project Management and Coordination v1) has effectively established project infrastructure, conducted regular meetings, and ensured quality control across all deliverables, while also developing a comprehensive DMP and outlining the project's security, ethical, legal, and privacy requirements.

WP3 (Risk Assessment and Requirements Definition) successfully completed risk assessments, defined user requirements and use case scenarios, established the legal and ethical framework for the project, and designed the technical architecture that will guide the efficient realization of the TESTUDO platform.

WP4 (Augmented Sensing and Communications for Effective Autonomy v1) made substantial progress in developing the Autonomous Fleet Coordinator module, implementing a robust communication layer, advancing 3D mapping capabilities and creating the TESTUDO interoperable data model for CI.

WP6 (Artificial Cognitive Intelligence for Threat Identification v1) advanced AI-based cognitive models for surveillance and threat detection, contributing to improved situational awareness. It also focused on developing embedded platform variations and the integration of multi-spectral imaging, CBRN detection, and cyber-threat analysis capabilities.

WP8 (Predictive Intelligence, Operational Support, and Platform Implementation v1) developed initial versions of multimodal fusion techniques, prediction models, and the monitoring centre with improved HMI. Additionally, WP8 successfully integrated key components during UC1 integration tests, laying the foundation for further module integrations.

WP11 (Impact Creation and Outreach v1) implemented a comprehensive dissemination plan and toolkit, engaged stakeholders, initiated market analysis and exploitation strategies, and began translating project findings into policy recommendations to maximize TESTUDO's impact on CIP.

The TESTUDO project has established a strong foundation for the development of its autonomous swarm platform for critical infrastructure protection. The initial functional modules developed across various work packages demonstrate promising advancements in AI-driven threat detection, predictive intelligence, and autonomous coordination. The project's focus on user-driven requirements and real-world use cases ensures that the final solution will be well-aligned with operational needs.

Future efforts will integrate components into the TESTUDO platform, ensuring GDPR and AI Act compliance, and enhance model accuracy through testing and real-data integration. Key activities include executing UC2 and UC3 to demonstrate a TRL7 prototype that highlights the platform's modularity, flexibility, and robustness. Additionally, the consortium will promote project results, pursue exploitation opportunities, collaborate with stakeholders, and influence CI protection policy.

The project's current status indicates a high likelihood of delivering a robust, flexible, and modular security platform for CIs, with the consortium committed to addressing technical, ethical, and real-world challenges, positioning TESTUDO for significant impact in Critical Infrastructure Protection.